# Exit Nozzle — Leader Guide

**Description:** Learners test how the size of an exit nozzle affects the force of the exhaust.

**Background:** The exit nozzle is the area of an engine where high velocity flow exits the engine and generates thrust to project a vehicle. The shape of the exit nozzle is designed so that the velocity of the exhaust gases continually increases as they exit the engine. Some fighter aircraft have the ability to adjust the shape of the exit nozzle in order to meet certain flight needs. In this activity, learners will investigate how the length of the exit nozzle affects the force of the exhaust by using a hair dryer and a cotton ball.

**National Science Standards**[1]

**K-2 Physical Sciences**

*Understands forces and motion*

Knows that the position and motion of an object can be changed by pushing or pulling

**3-5 Nature of Science**

*Understands the nature of scientific inquiry*

Plans and conducts simple investigations

**3-5 Physical Sciences**

*Understands forces and motion*

Knows that an object's motion can be described by tracing and measuring its position over time

Knows that when a force is applied to an object, the object either speeds up, slows down, or goes in a different direction

[1]Kendall, J.S. & Marzano, R.J. (2000). *Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education.* (3rd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

**Materials**

For each group or pair:

- Hair dryer (with a cool setting)
- Construction paper or file folders (to create nozzles)
- Cotton ball
- Meter stick
- Transparent tape (to form the nozzle)
- Electrical tape (to secure nozzle to hair dryer)
- Masking tape (for starting line)
- Write-On Sheet, "Exit Nozzle"

**Note**

Different hair dryers may produce different results. Such differences present additional learning opportunities as learners identify additional variables (e.g., diameter of hair dryer nozzle, power level of motor, etc.).

**Advanced Preparation:**
Obtain enough hair dryers (with a cool setting) for each group of learners to have one. If your group is short on time, you may want to pre-cut the construction paper so that it can be rolled to create long exit nozzles (30 to 45 centimeters in length) and short exit nozzles (18 to 24 centimeters in length). Another option could be to roll letter-sized file folders. The longer exit nozzle could be created by opening a file folder and rolling it lengthwise. The shorter exit nozzle could be a closed file folder. Roll them in such a way that each nozzle can be taped securely to the dryer. If you allow the participants to do this preparation, you may want to have one completed so they have a model for how it is done.

**Procedure:**

1. Ask learners to relate a time that they saw an airplane flying in the sky. Ask them to describe what it looked like. Lead them to talking about the contrail that can be seen as a white line behind the plane. Ask students what they think a contrail is and why an airplane makes it. (Learners may note that it is exhaust coming from the engine of the airplane.)

2. Ask learners if they have ever been on a plane or seen an airplane engine close up. Explain that they will conduct an experiment where they will compare the **thrust** *(the power to push forward or up)* made by a long **exit nozzle** *(a tube-shaped extension that accelerates the exhaust engines from a motor)* and a short exit nozzle.

3. Learners should begin by writing a question that deals with the length of the exit nozzle. Encourage participants to avoid writing questions that can be answered with a "yes" or "no" response. They should include the variables (factors) that are to be tested. An example of a question for this investigation is: "How does the length of the exit nozzle affect the amount of thrust produced?"


Pilot test educator tests the effects of a longer exit nozzle.

4. Provide the materials and "Write-On" Sheets to the small groups (or partners depending on size of group). Monitor participants so that they are working safely with the materials. Offer any assistance that they might need to complete the procedure.

5. Provide the space for the groups to test their exit nozzles. Floors with a smooth surface may produce different results than a carpeted area. Mark the starting line with a strip of masking tape. Instruct learners to record their results in the data

table. Once participants have completed the testing, ask them to answer the questions. Emphasize that their conclusions should answer the question and include data from the table.

6. Ask someone from each group to report their distances. Ask questions similar to the following:
   - Why are the average distances different? (Each group used different materials.)
   - What would cause some of these differences? (Learners should list variables that were not kept constant.)
   - How do the averages compare with your group's distances? (Answers will vary.)

7. Challenge learners to complete an investigation similar to this one, only this time, ask them to change the shape of the exit nozzle. Each group can complete an investigation similar to this or design their own.

This activity was adapted for Community Quest from an activity in the Genesis education module *Dynamic Design: Launch and Propulsion* found at: http://www.genesismission.org/educate/scimodule/Launch_Propulsion.html

**Resources for Extension and Enrichment Activities**

http://chicago.space-explorers.com/internal/mss/teachers/lessons/module4/ellessons/CAI/lesson9.pdf
In this Space Explorers lesson, elementary-aged students learn how rockets work through a balloon simulation.

http://genesismission.jpl.nasa.gov/educate/scimodule/LaunchPropulsion/L&P_PDFs/D4_SAwhatadrag.pdf
"What a Drag!" is a hands-on learning activity from NASA's Genesis mission education materials. Learners investigate the effects of nose-cone shapes and sizes on a water rocket's aerodynamics.